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Light Integrator and Koehler Illumination System Including Same

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Specification

1. Title of the Invention

Light Integrator and Koehler Illumination System Including Same

2. Claims

Claim 1

A light integrator, wherein segment lenses, each having a cross sectional shape, in a plane perpendicular to the optical axis, that is the same as the shape of a desired irradiation region, are closely arranged in a plane perpendicular to the optical axis.

Claim 2

The light integrator of claim 1, wherein the cross sectional shape is a circular arc shape or a fan shape.

Claim 3

The light integrator of claim 1, wherein the cross sectional shape is a convex shape circumscribing a circular arc shape or a fan shape.

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Claim 4

A Koehler illumination system, containing a light integrator comprising segment lenses, each having a cross sectional shape, in a plane perpendicular to the optical axis, that is the same as the shape of a desired irradiation region, and which are closely arranged in a plane perpendicular to the optical axis.

3. Detailed Description of the Invention

[Field of Industrial Application]

The present invention relates in general to a light integrator and a Koehler illumination system including the light integrator, and more specifically to a light integrator and a Koehler illumination system including the light integrator for an illumination optical system of a scanning type projection exposure device which transfers a semiconductor circuit pattern by synchronously scanning a mask and a wafer using an aperture with a circular arc shape or a fan shape.

[Prior Art Technology]

One of the methods of transferring fine integrated circuit patterns on a mask to a semiconductor wafer is a unity magnification system mirror scanning type projection exposure apparatus. The advantages of this method are higher throughput, better yield and better resolution than those of the step and repeat method, contact or close exposure apparatus.

As shown in Fig. 3, a unity magnification system mirror scanning type exposure apparatus uses a reflective projection system R having a concave mirror 11 and convex mirror 12 and an illumination system K forming a circular arc shaped or fan shaped irradiation region, and synchronously scans a mask 7 in an object plane and a wafer 14 in an image forming plane, with the mask 7 and wafer 14 being scanned respectively in the object and image forming planes in the arrow direction. Reference numerals 10 and 13 represent folding mirrors. In an illumination method of this type of projection system, it is necessary to illuminate all of a circular arc shaped or a fan shaped good image region uniformly and at good efficiency, at a specific aperture number.

The illumination optical system used here has a cylindrical fly-eye lens 3 as a light integrator at its pupil position, and a light source 1 is formed on this fly-eye lens 3. By using such a Koehler illumination system, a uniform effective light source is obtained at all points in the circular arc shaped or fan shaped irradiation region on the mask, without uneven illumination intensity. However, a rectangular irradiation region is formed with a cylindrical fly-eye lens at first, then a circular arc shaped or fan shaped slit is placed on this irradiation region, and a circular arc shaped or fan shaped irradiation region is projected onto the mask 7 through the slit. Therefore, there has been a problem that the illumination efficiency decreases because, of the luminous flux irradiating the rectangular irradiation region, only the luminous flux passing through the circular arc shaped or fan shaped slit is used.

[Problems the Invention Aims to Resolve, and Resolution Means]

An object of the present invention is to solve the above-mentioned problems, more specifically to provide a light integrator to efficiently illuminate an irradiation region of a desired shape.

According to the present invention, this object is achieved by forming a light integrator, wherein segment lenses, each having a cross sectional shape, in a plane perpendicular to the optical axis, that is the same as the shape of a desired irradiation region, for example a circular arc shape or a fan shape, are closely arranged in a plane perpendicular to the optical axis. Thereby, an irradiation region of a desired shape, such as a circular arc shape or a fan shape, is directly formed on the irradiation target surface.

[Embodiment]

Fig. 1 is a perspective view of a light integrator in accordance with the present invention. Fig. 2 is a perspective view of a segment lens of the light integrator of Fig. 1.

In Fig. 1, in accordance with present invention, the light integrator 3 has a sectional shape, in a plane (XY plane) perpendicular to the optical axis (Z axis), that is the same shape as that of the desired irradiation region. That is, in the present embodiment, the light integrator 3 has a structure such that segment lenses (see Fig. 2), each being formed in a circular arc shape or a fan shape, are closely arranged in the XY plane.

In Fig. 2, a segment lens of a cylindrical fly-eye lens is shown in a dot-dashed line. According to the present invention, this segment lens of a cylindrical fly-eye lens is cut into a thin segment lens such that a cross section in the XY plane becomes a circular arc shape or a fan shape. As shown in Fig. 1, a plurality of the segment lenses are closely arranged in horizontal and vertical directions to construct a fly-eye block.

Fig. 3 shows a unity magnification system mirror scanning type projection exposure apparatus using the light integrator of the present invention. In Fig. 3, reference numeral 1 indicates an illumination light source, for example a super high pressure mercury-arc lamp. 2 indicates an elliptical mirror, and the illumination light source 1 is placed at a first focal point thereof. 3 indicates the light integrator of the present invention. 4 indicates a collimator lens, and light spots of the light integrator 3 are arranged at a first focal point of the collimator lens 4 and a mask plane (image forming plane) 5 is arranged at a second focal surface of the collimator lens 4. A Koehler illumination system K is thus formed. 6 indicates a collimator lens.

The light emitted from the super high pressure mercury-arc lamp 1 is focused on the light integrator 3 by the elliptical mirror 2, the light emitted from each point of the light integrator 3 is turned into parallel rays by the action of the collimator lens 4, and the parallel rays irradiate the mask plane 5.

That is, a multi-luminous flux Koehler illumination of the mask 5 is effected. (In Fig. 4, the circular arc-shaped or fan-shaped irradiation region projected on the mask 5 is shown tilted 90° forward from the plane of the mask 5.)

A circular arc-shaped or fan-shaped irradiation region can be formed at the position of the mask 5, and this will be explained further by referring to Fig. 4.

In Fig. 4, taking a point P_0 on the light source side of the fly-eye lens 3, this forms an image at the point P_0' on the image forming plane 5 because of its optically conjugate relationship with the image forming plane 5. Similarly, images of points P_1, P_2 are formed at points P_1' and P_2' , respectively. The corresponding point on adjacent segment lenses, for example points Q_0 and R_0 corresponding to the point P_0 , form the same point P_0' on the image forming plane 5, similar to the operation of a conventional fly-eye lens. In this way, the shapes of each segment lens (circular arc shapes or fan shapes) are superimposed at the same position on the image forming plane 5.

The luminous flux from the light source 1 focused on each segment lens of the fly-eye lens is focused in a circular arc shape or a fan shape on the image forming plane 5 by the action of the fly-eye block 3 to increase the efficiency of the illumination system. At this time, the shape of the effective light source is determined by the outer frame of the fly-eye block, but the shape of the outer frame in the case of the present embodiment is rectangular.

In the present embodiment, to form a circular arc shaped or fan shaped irradiation region, the sectional shape perpendicular to the optical axis is a circular arc shape or a fan shape. However, for the sake of convenience in processing, a convex shape circumscribing a circular arc shape or a fan shape may be used.

Other shapes of the irradiation region includes rectangular, regular hexagon and diamond shapes. By slicing the segment lenses is to form shapes such as these, and closely arranging a plurality of them, a light integrator with a highly efficient irradiation region can be formed.

[Efficacy of the Invention]

As clearly described above, in the present invention, the illumination efficiency can be increased as the irradiation region is directly formed to match the desired irradiation region shape. The same effective light source image can be obtained at all points on the irradiation region, without uneven illumination. The size and shape of the effective light source can be selected arbitrarily by adjusting the size and the shape of the fly-eye lens to provide design advantages.

4. Brief Description of the Drawings

Fig. 1 is a perspective view of a light integrator of an embodiment in accordance with the present invention. Fig. 2 is a perspective view of a segment lens used to form a light integrator in accordance with the present invention.

Fig. 3 shows a simplified diagram of a unity magnification system mirror scanning type projection exposure apparatus using the light integrator of the present invention and a Koehler illumination system including the same.

Fig. 4 is an explanatory drawing to show the action of the light integrator in the present invention.

- 1: light source
- 2: elliptical mirror
- 3: light integrator
- 4, 6: collimator lenses
- 5: image forming plane
- 7: mask
- 10, 13: folding mirror
- 11 :concave mirror
- 12: convex mirror
- 14: wafer
- K: Koehler illumination system
- R: reflective type projection system

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Fig. 1

Fig. 2

Fig. 3

Fig. 4